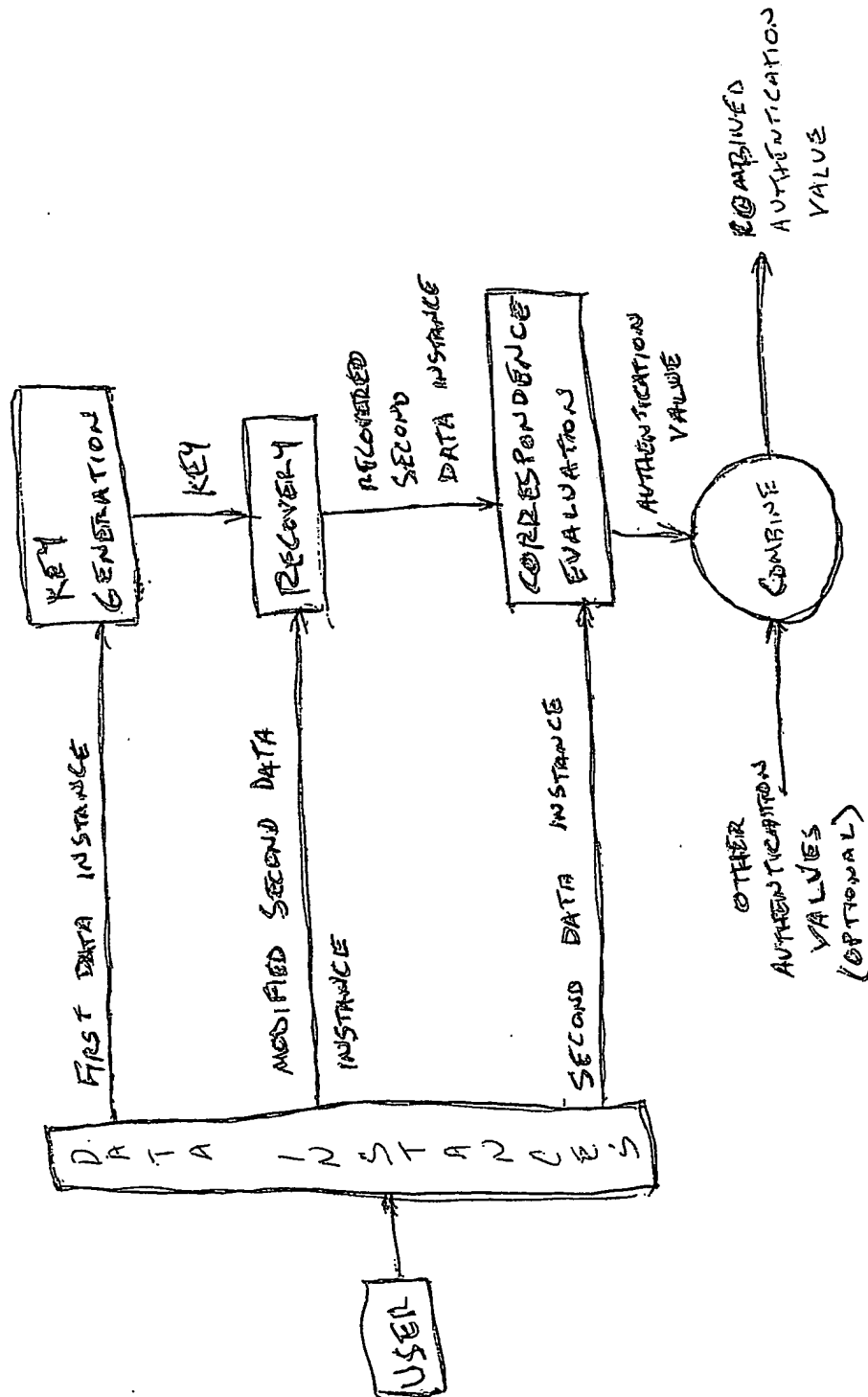


FIG. 1

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Fig. 2



Multi-Factor Member Identification (Encrypted SN + Fingerprint)

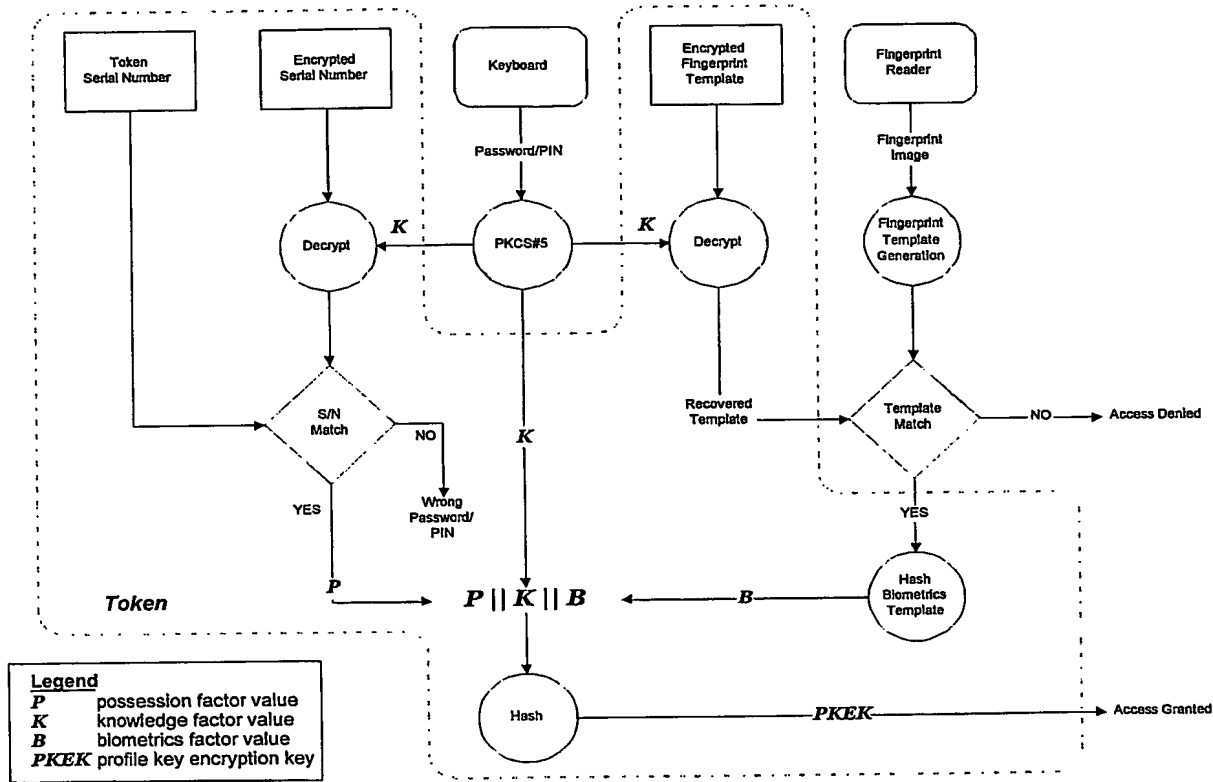


Fig. 3

Fig. 4

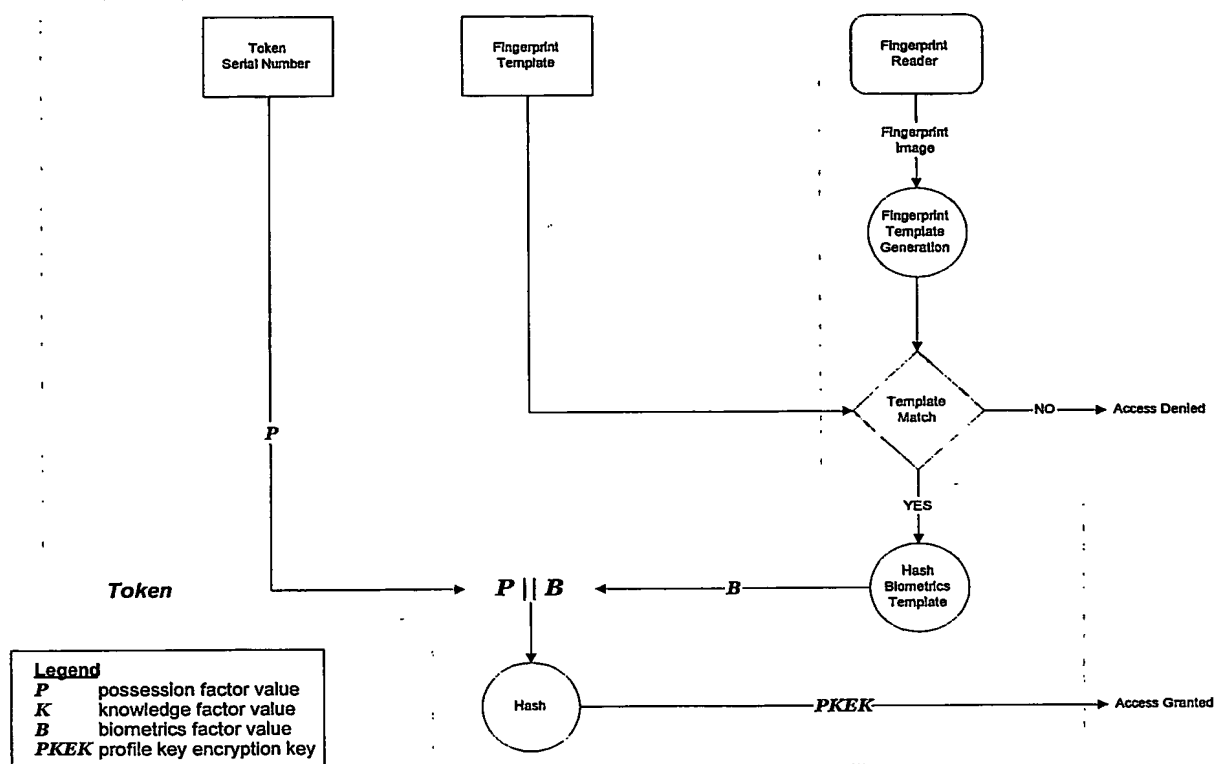
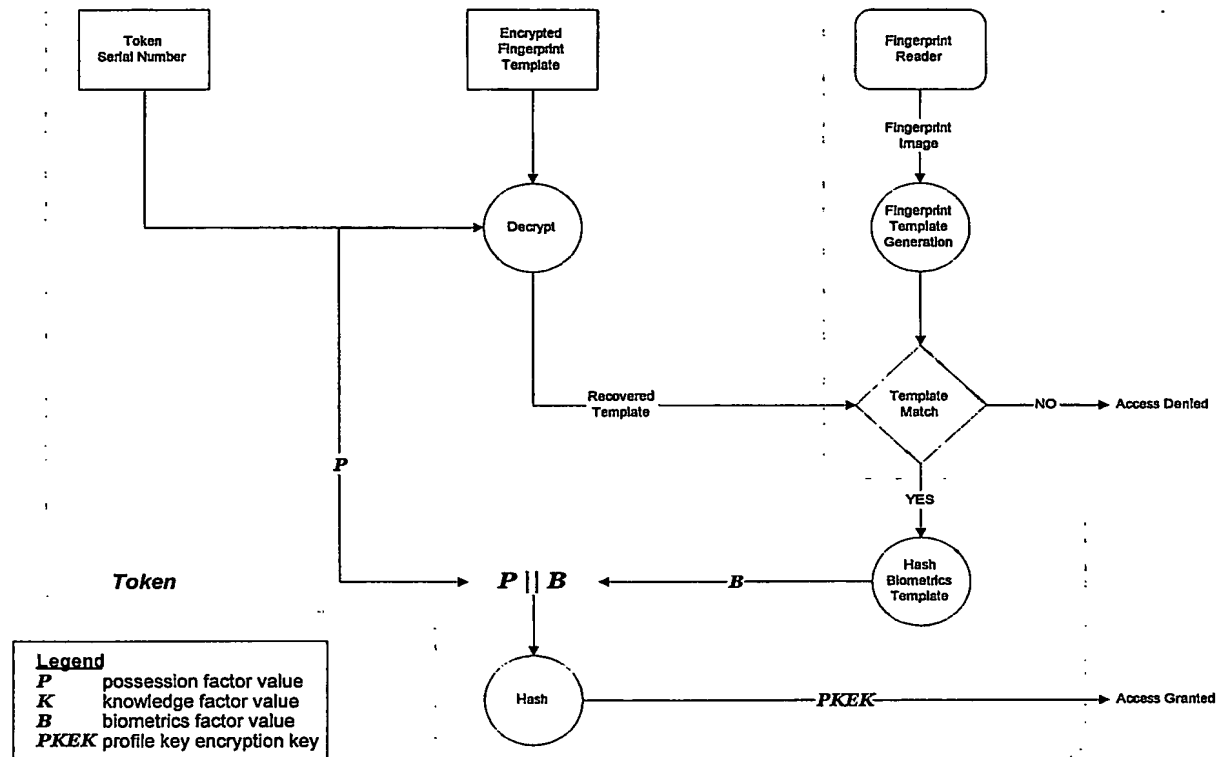
Two-Factor Identification (Token + Fingerprint)

Fig. 5

Two-Factor Identification (Token + Fingerprint w/Encrypted Template)

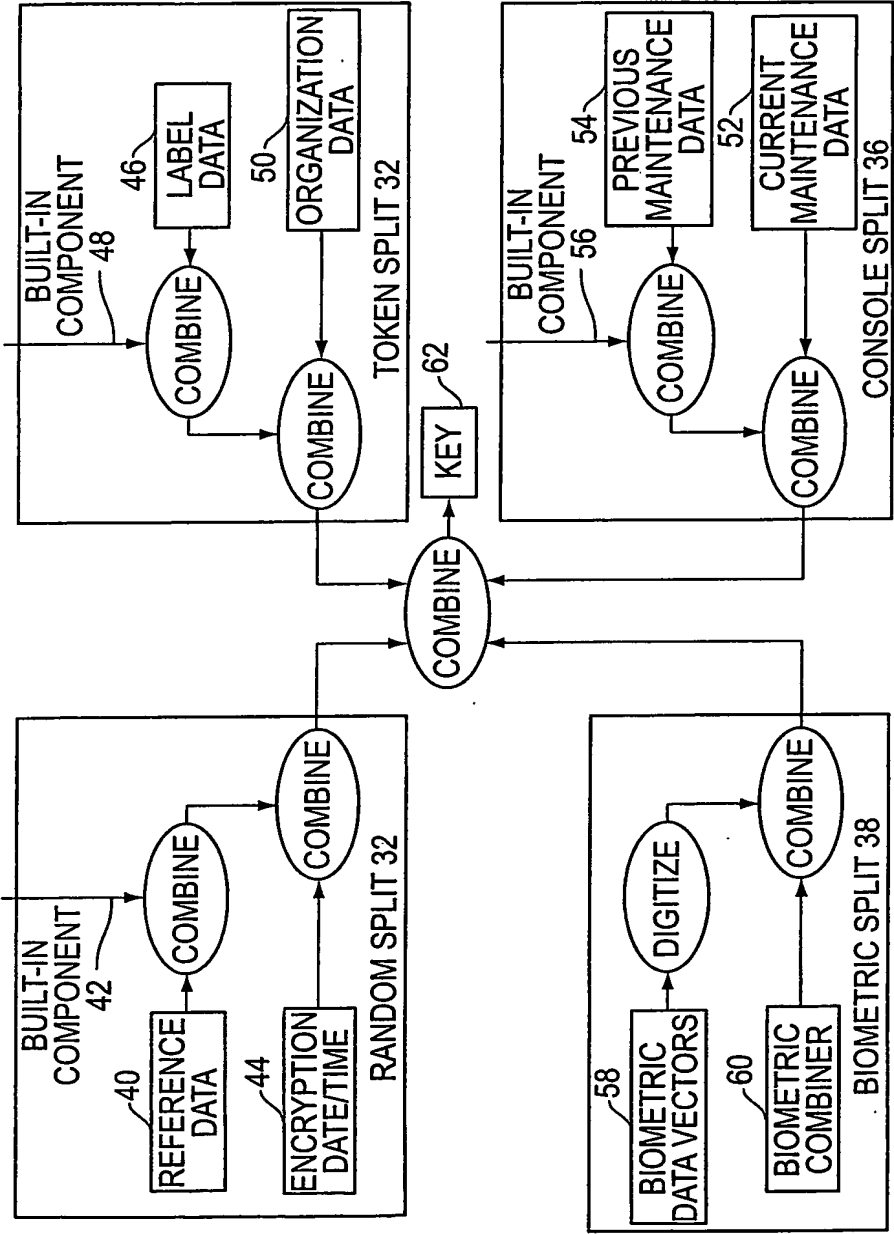


FIG. 6

Number	Decrypt	Encrypt	Number	Decrypt	Encrypt	Number	Decrypt	Encrypt
1	—	—	4	↑	—	7	↓	—
2	—	↑	5	↑	↑	8	↓	↑
3	—	↓	6	↑	↓	9	↓	↓

Fig. 7

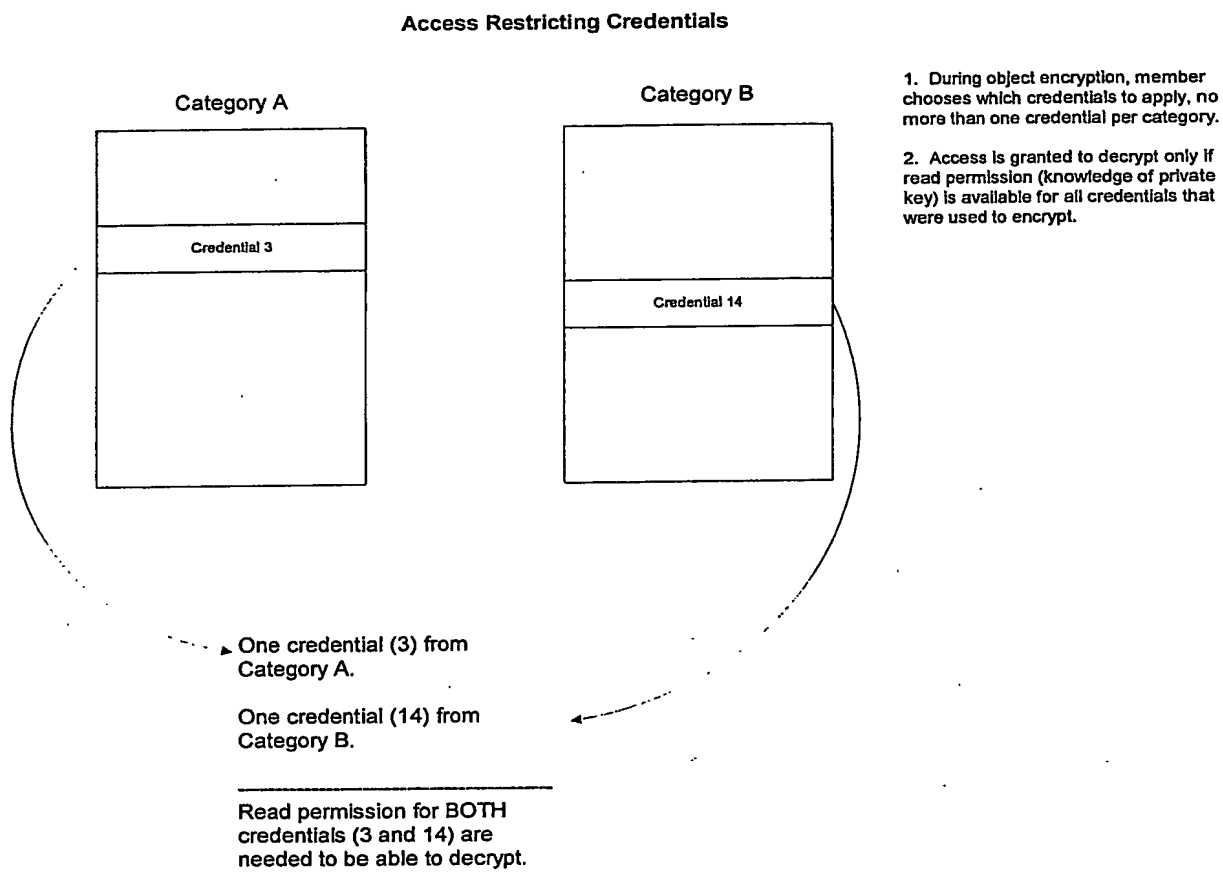


Fig. 8

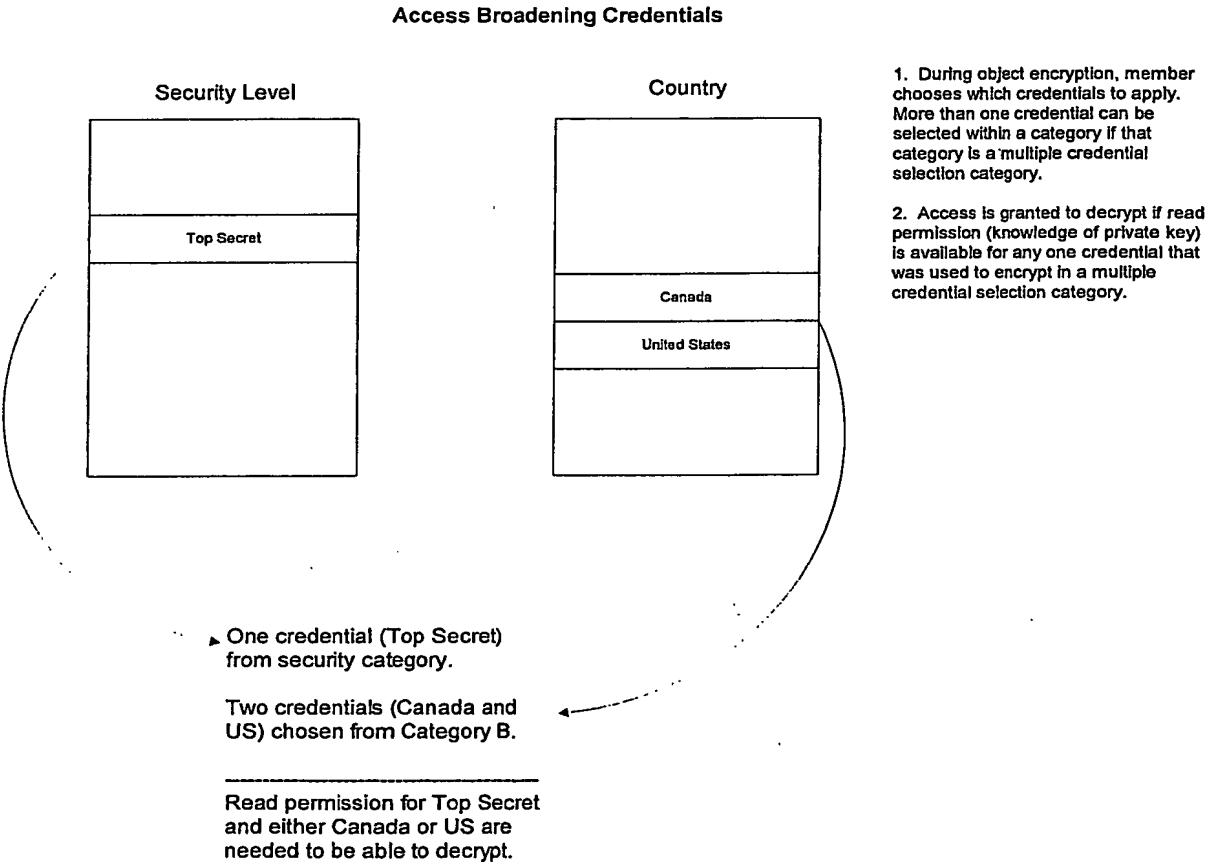


Fig. 9

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Threshold Method for Multiple Credential Selection Category

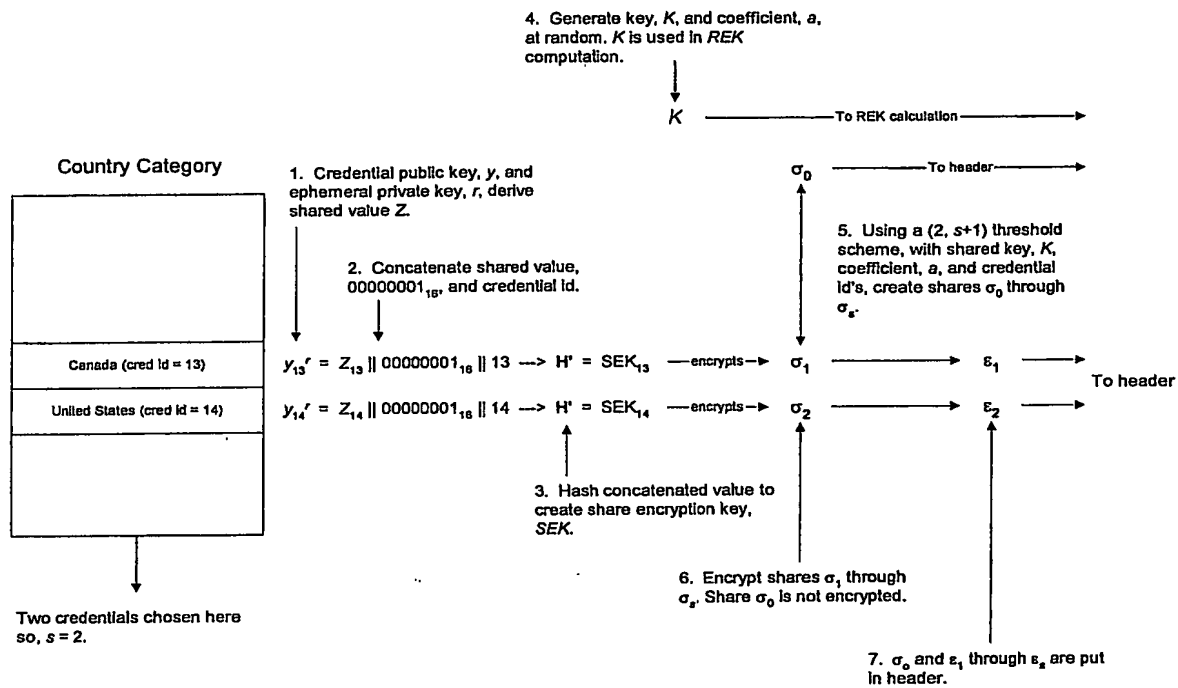


Fig. 10

Access Type	Set of Available Credentials
1	$\{(\forall c \in P \exists x_c \in c \wedge \lambda_c = \lambda_{IA}) \cup (\forall c \in P \exists y_c \in c \wedge \lambda_c = \lambda_{IA})\}$
2	$\{(\forall c \in P \exists x_c \in c \wedge \lambda_c = \lambda_{IA}) \cup (\forall c \in P \exists y_c \in c \wedge \lambda_c \geq \lambda_{IA})\}$
3	$\{(\forall c \in P \exists x_c \in c \wedge \lambda_c = \lambda_{IA}) \cup (\forall c \in P \exists y_c \in c \wedge \lambda_c \leq \lambda_{IA})\}$
4	$\{(\forall c \in P \exists x_c \in c \wedge \lambda_c \geq \lambda_{IA}) \cup (\forall c \in P \exists y_c \in c \wedge \lambda_c = \lambda_{IA})\}$
5	$\{(\forall c \in P \exists x_c \in c \wedge \lambda_c \geq \lambda_{IA}) \cup (\forall c \in P \exists y_c \in c \wedge \lambda_c \geq \lambda_{IA})\}$
6	$\{(\forall c \in P \exists x_c \in c \wedge \lambda_c \geq \lambda_{IA}) \cup (\forall c \in P \exists y_c \in c \wedge \lambda_c \leq \lambda_{IA})\}$
7	$\{(\forall c \in P \exists x_c \in c \wedge \lambda_c \leq \lambda_{IA}) \cup (\forall c \in P \exists y_c \in c \wedge \lambda_c = \lambda_{IA})\}$
8	$\{(\forall c \in P \exists x_c \in c \wedge \lambda_c \leq \lambda_{IA}) \cup (\forall c \in P \exists y_c \in c \wedge \lambda_c \geq \lambda_{IA})\}$
9	$\{(\forall c \in P \exists x_c \in c \wedge \lambda_c \leq \lambda_{IA}) \cup (\forall c \in P \exists y_c \in c \wedge \lambda_c \leq \lambda_{IA})\}$

Fig. 11

Access Type	xek_c	yek_c	Independent Read Value	Independent Write Value
1	$xek_c = \kappa_\lambda$	$yek_c = \kappa_\lambda$	N/A	N/A
2	$xek_c = \kappa_\lambda$	$yek_c = (H^{(\lambda_c-1)}(yek_1)) / 2^{(h-k)}$	N/A	yek_1
3	$xek_c = \kappa_\lambda$	$yek_c = H^{(s-\lambda_c)}(yek_s) / 2^{(h-k)}$	N/A	yek_s
4	$xek_c = (H^{(\lambda_c-1)}(xek_1)) / 2^{(h-k)}$	$yek_c = \kappa_\lambda$	xek_1	N/A
5	$xek_c = (H^{(\lambda_c-1)}(xek_1)) / 2^{(h-k)}$	$yek_c = (H^{(\lambda_c-1)}(yek_1)) / 2^{(h-k)}$	xek_1	yek_1
6	$xek_c = (H^{(\lambda_c-1)}(xek_1)) / 2^{(h-k)}$	$yek_c = H^{(s-\lambda_c)}(yek_s) / 2^{(h-k)}$	xek_1	yek_s
7	$xek_c = H^{(s-\lambda_c)}(xek_s) / 2^{(h-k)}$	$yek_c = \kappa_\lambda$	xek_s	N/A
8	$xek_c = H^{(s-\lambda_c)}(xek_s) / 2^{(h-k)}$	$yek_c = (H^{(\lambda_c-1)}(yek_1)) / 2^{(h-k)}$	xek_s	yek_1
9	$xek_c = H^{(s-\lambda_c)}(xek_s) / 2^{(h-k)}$	$yek_c = H^{(s-\lambda_c)}(yek_s) / 2^{(h-k)}$	xek_s	yek_s

Fig. 12

Profile Encryption

<p>Encrypted Profile Encryption Keys</p> $\begin{aligned} ePEK_1 &= e(PEK, \kappa_1) \\ ePEK_2 &= e(PEK, \kappa_1) \\ &\vdots \\ ePEK_{\lambda_{max}} &= e(PEK, \kappa_{\lambda_{max}}) \end{aligned}$	<p>Encrypted Credential Private and Public Key Encryption Keys</p> $\begin{aligned} exek_1 &= e(xek_1, \kappa_1) & eyek_1 &= e(yek_1, \kappa_1) \\ exek_2 &= e(xek_2, \kappa_2) & eyek_2 &= e(yek_2, \kappa_2) \\ &\vdots & &\vdots \\ exek_{\lambda_{max}} &= e(xek_{\lambda_{max}}, \kappa_{\lambda_{max}}) & eyek_{\lambda_{max}} &= e(yek_{\lambda_{max}}, \kappa_{\lambda_{max}}) \end{aligned}$
<p>Encrypted Profile</p> $eProfile = e(Profile, PEK)$	<p>Encrypted Credential Private and Public Keys</p> $\begin{aligned} ex_1 &= e(x_1, xek_{\lambda(1)}) & ey_1 &= e(y_1, yek_{\lambda(1)}) \\ ex_2 &= e(x_2, xek_{\lambda(2)}) & ey_2 &= e(y_2, yek_{\lambda(2)}) \\ &\vdots & &\vdots \\ ex_n &= e(x_n, xek_{\lambda(n)}) & ey_n &= e(y_n, yek_{\lambda(n)}) \end{aligned}$

Fig. 13

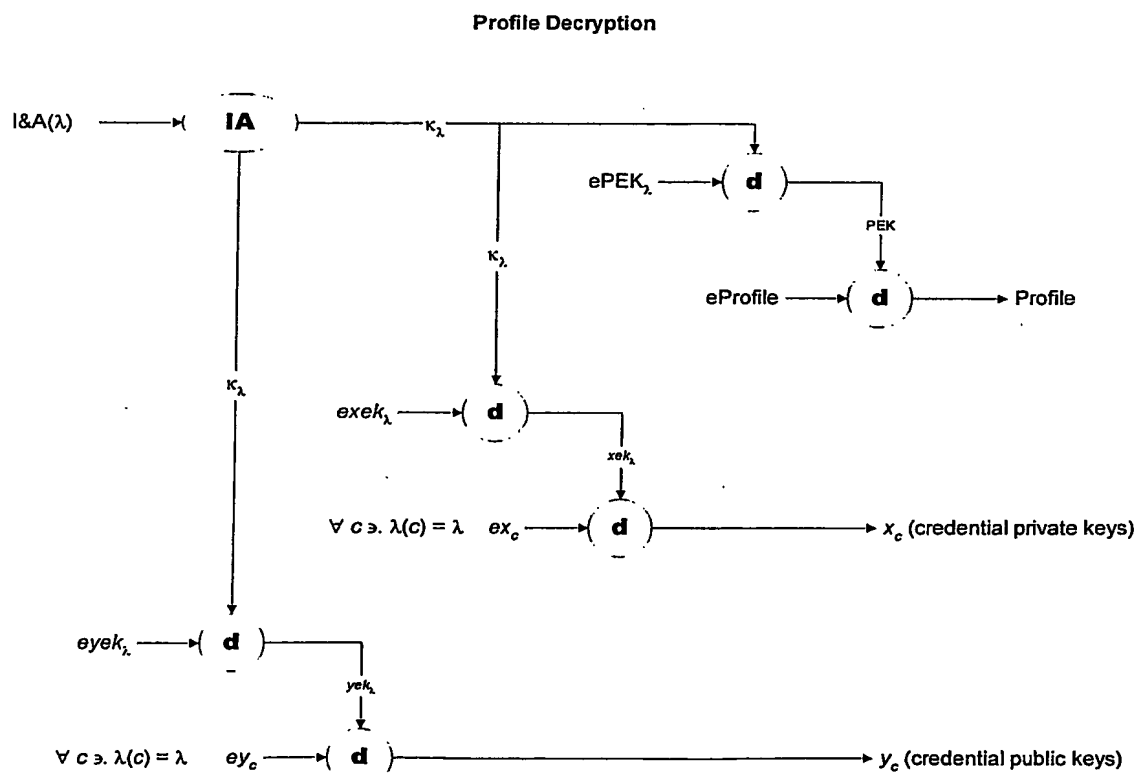
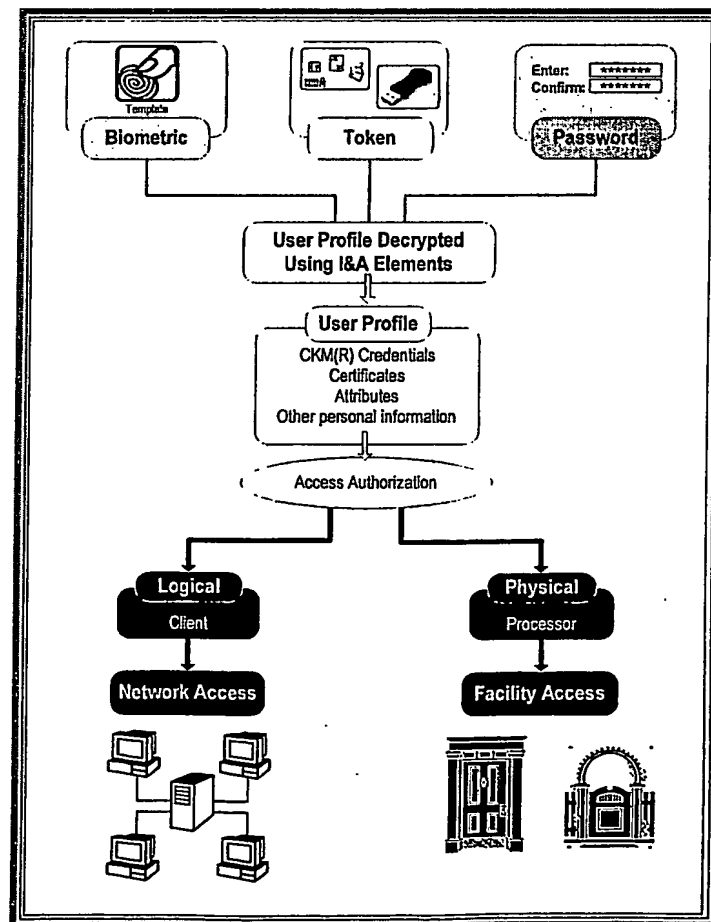


Fig. 14

Fig. 15



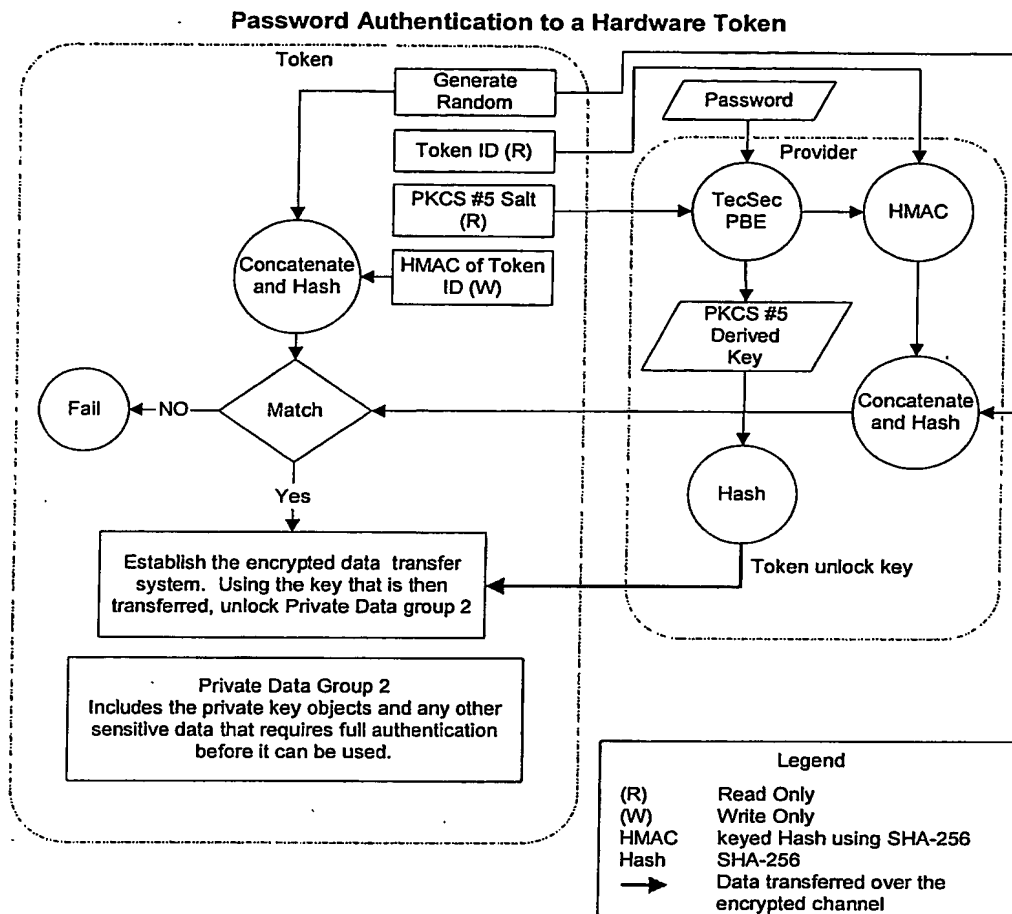


Fig. 16

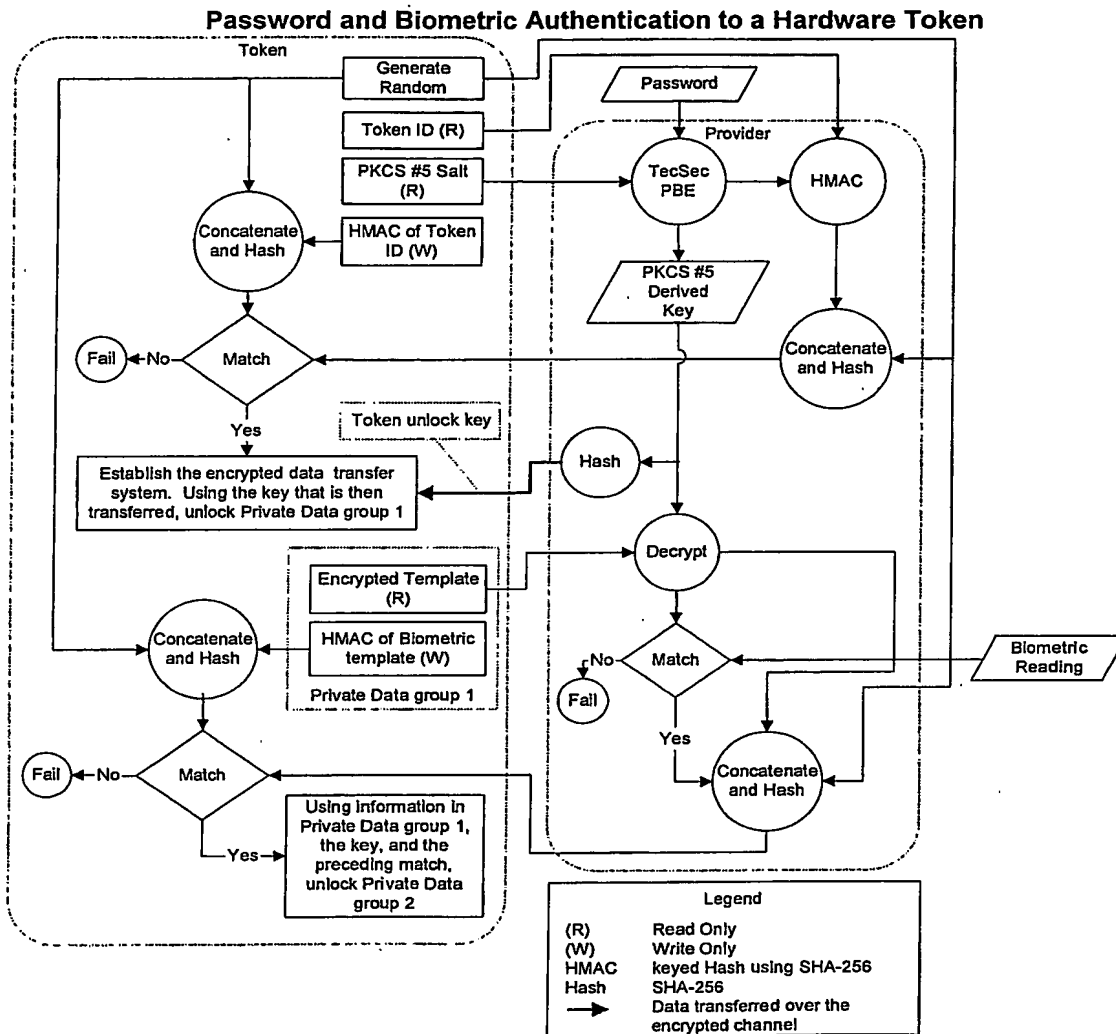


Fig. 17

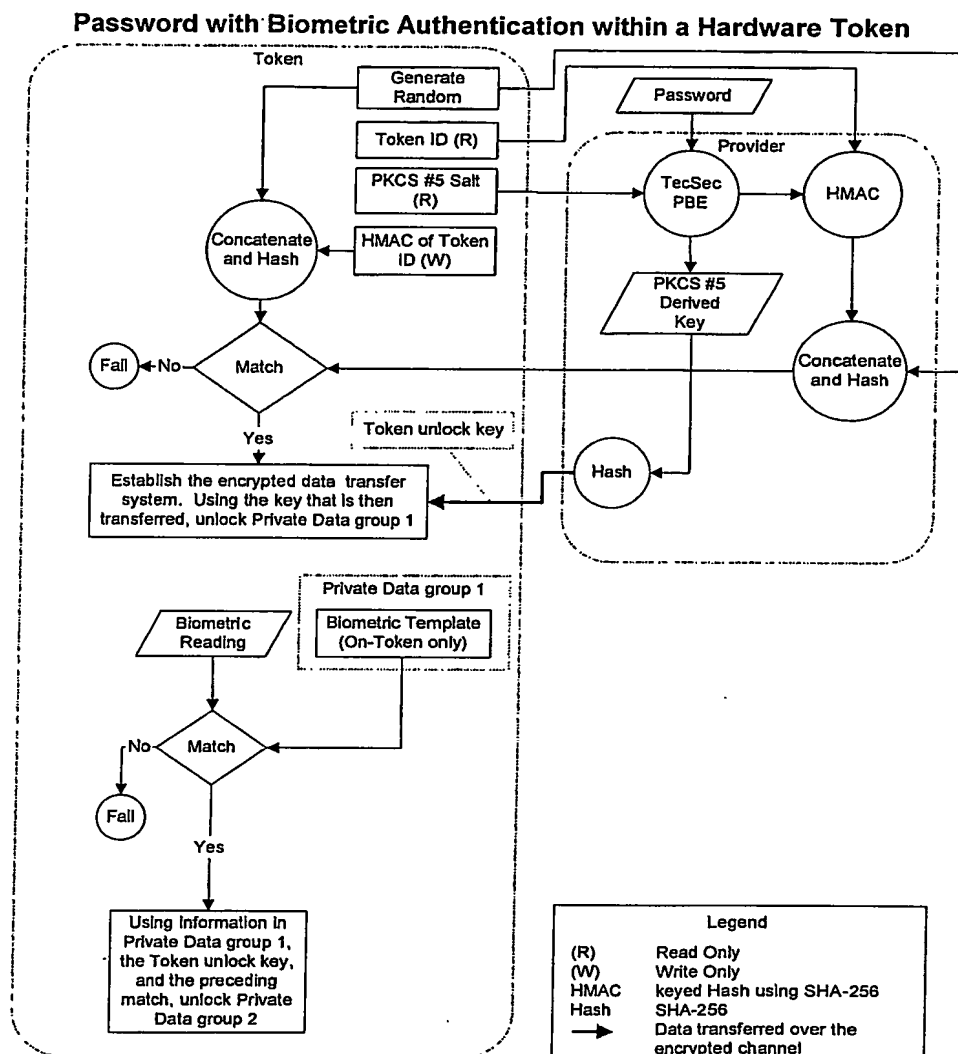


Fig. 18

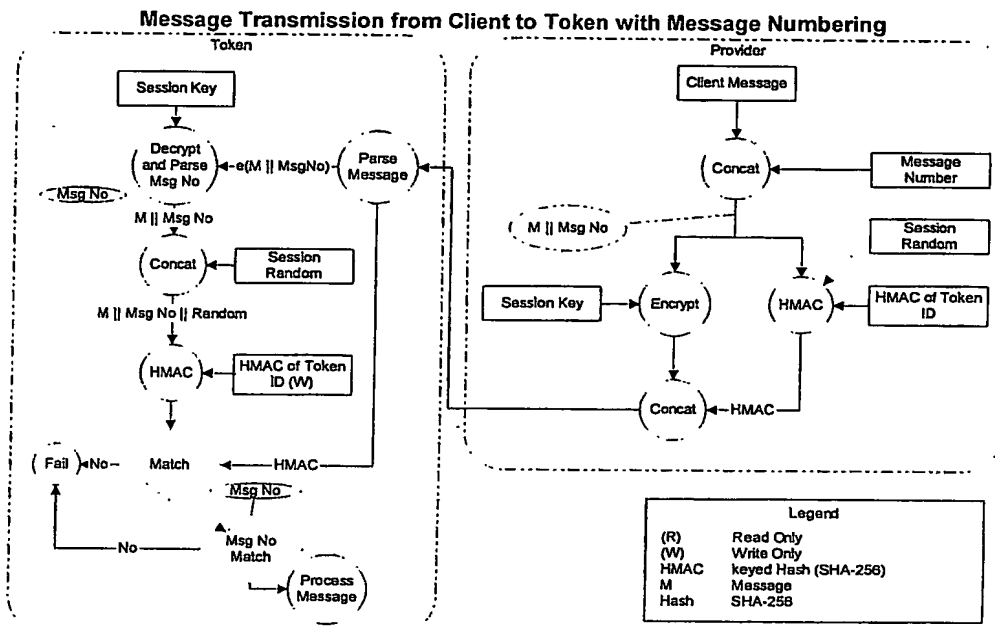


Fig. 19

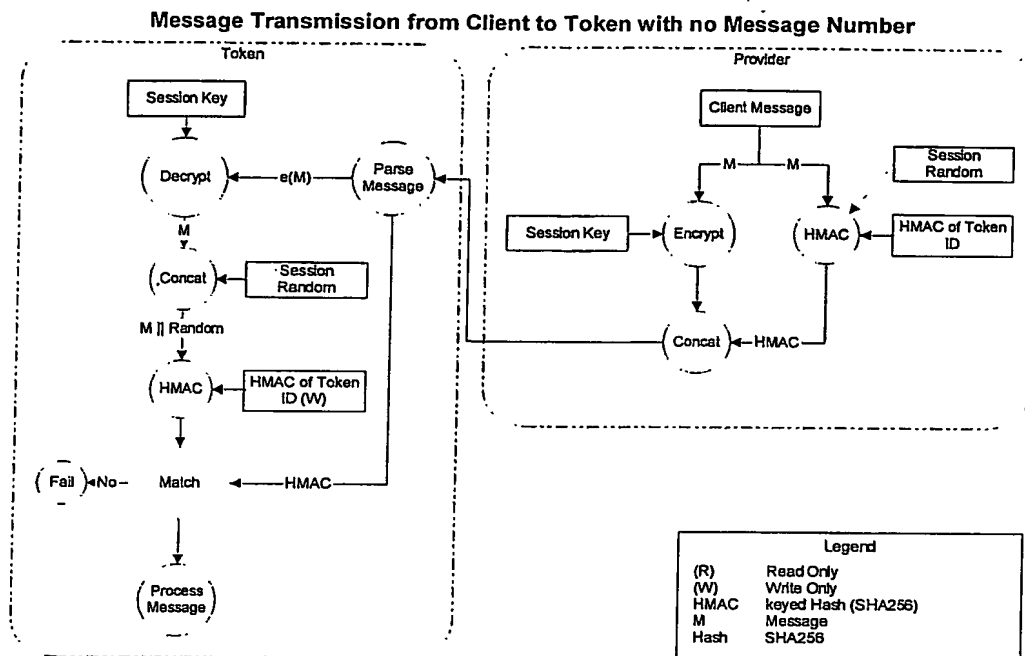


Fig. 20

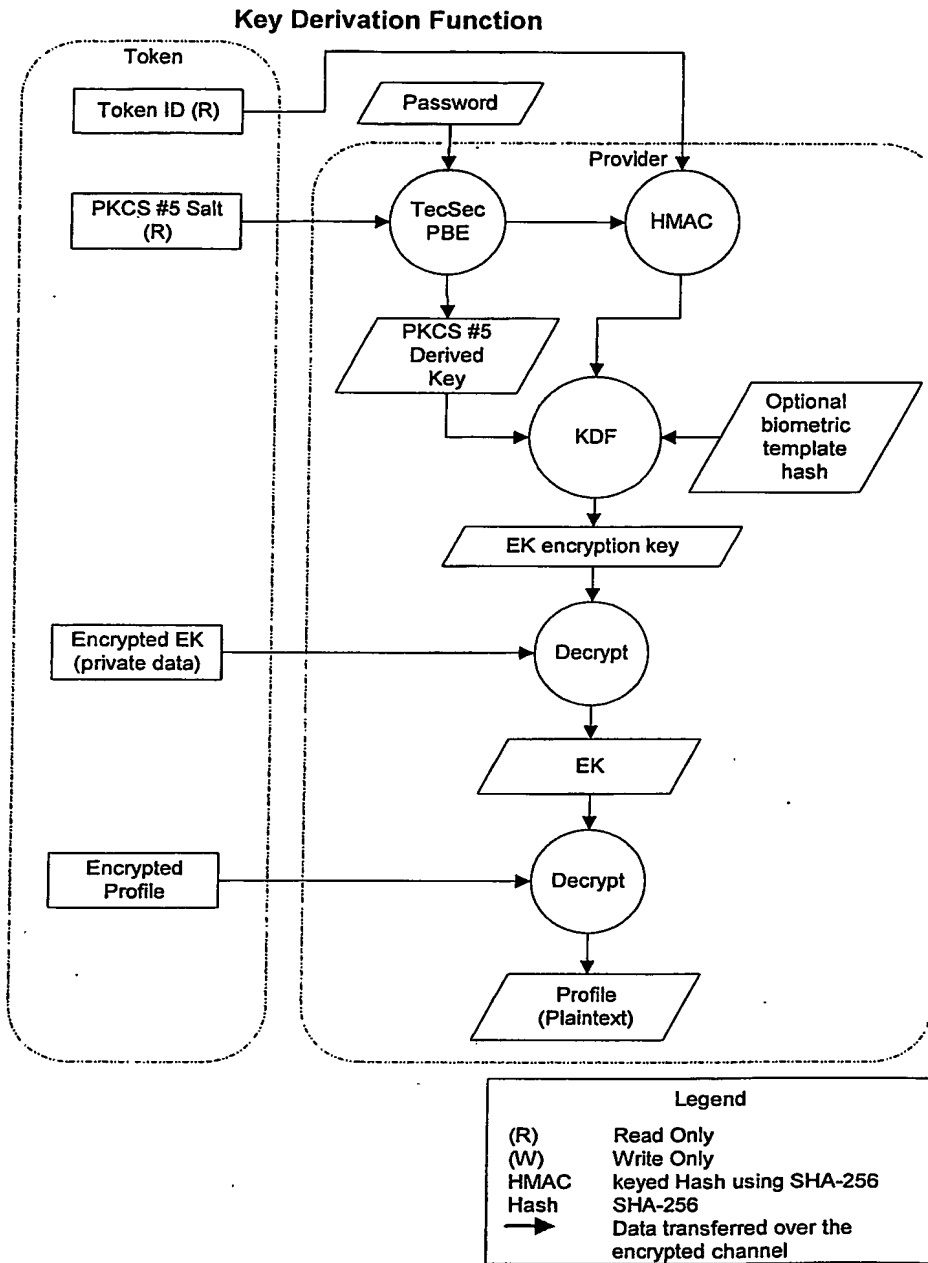


Fig. 21

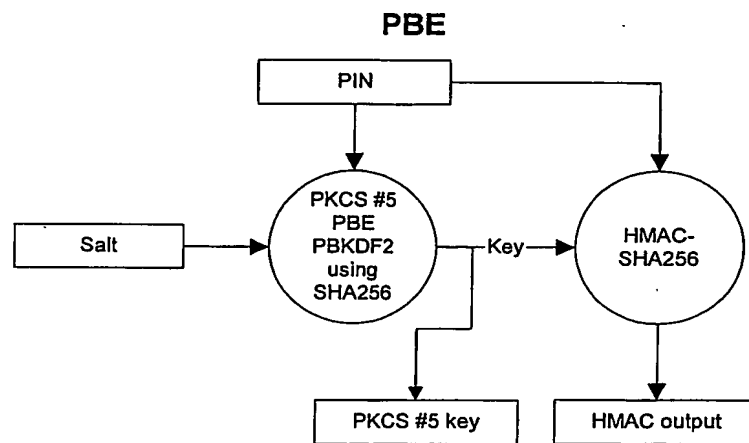


Fig. 22

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